The cor solo

The *Cor Solo*: History and Characteristics

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By the end of the eighteenth century, four main types of French horn had been developed:

- The fixed-pitch instrument
- Instruments with tuning-slide crooks
- Instruments with terminal crooks
- Instruments with both terminal and tuning-slide crooks.

The focus here is on instruments from the second category—those crooked with tuning-slide or "internal" crooks (alternative tuning-slides of different tube lengths), generally known as the *Inventionshorn* and in particular as the *cor solo*. Both instruments have an interchangeable main tuning slide in the middle of the body, rather than at the beginning, between the mouthpiece and the body. The earlier German design, the *Inventionshorn*, could be crooked into a larger number of tonalities than the later French design, known as the *cor solo*. The latter derives its name from the fact that it was predominantly made with five crooks, for G, F, E, E♭, and D, these being the keys of most solo and chamber music for the horn. The term *cor solo*, when given to such an instrument, can lead to some confusion because the identical term in French can denote the role of the principal of a horn section. Given the generally smaller range of crooks and the later emergence of the instrument, the *cor solo* design could be viewed as a specific French style of *Inventionshorn* with limited tonalities.[1] While the term itself does not appear to have been used regularly until the 1820s,[2] for the purposes of our survey we would suggest that the term be used to describe French horns with tuning-slide crooks made after Joseph Raoux's collaboration with Carl Türrschmidt in 1781, in which a style of *Inventionshorn* with crossed-over tubing prior to the tuning-slide crook was developed (see Figure 1).

Early histories of instruments with tuning-slide crooks

The *Inventionshorn* can be seen as the first attempt to make a horn supplied with tuning-slide crooks. Previously, horns had either been built in a fixed pitch or the pitch could be altered through terminal crooks and shanks. The earliest account of the *Inventionshorn* comes from Johann Nepomuk Forkel's article in the *Musikalischer Almanach für Deutschland* (1782),[3] in which the author refers to "Geier"[4] *Inventionshorns* that had been available for "six years," i.e., since ca. 1776. In his article on Anton Hampel in the *Neues historisch-biographisches Lexikon* (1812–14),[5] Ernst Ludwig Gerber dates the *Inventionshorn* as early as 1753–55 with Hampel's collaboration with the Dresden maker Johann Georg Werner.[6] Gerber credits Carl Türrschmidt[7] as the source of much of his information concerning horn players, having provided him with "whole written sheets, full of remarkable notes by German and French masters."[8] Recently

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Figure 1: *Cor solo* with five tuning-slide crooks (Marcel-Auguste Raoux, Paris, 1823), showing the tube leading into the tuning-slide from the mouthpipe crossing under the tube leading from the tuning-slide to the bell.
Edinburgh University Collection of Historic Musical Instruments (6144).

Renato Meucci has cast doubt on Gerber's assertion, suggesting that he had potentially misunderstood the information from Türrschmidt regarding the *Inventionshorn*, due to the term *Inventionshorn* having morphed from an older use of the term, used to describe a horn designed by Werner that was playable in nine different tonalities, into the more recent use of the term to describe the instrument with tuning-slide crooks.[9]

In 1784 an article by amateur flautist Johannes Heinrich Ribock in the *Magazin der Musik* refers to a "discovery" by an artisan in Hanau, whom we assume to be the maker Haltenhof.[10] In a footnote to this article the editor, Carl Friedrich Cramer, points out that this instrument is called an *Inventionshorn*, suggesting that the term was still not widely recognized. In his earlier *Historisch-biographisches Lexicon der Tonkünstler* (1790–92),[11] Gerber reiterates Ribock's story of the "artisan in Hanau." This story is uncredited there, as Gerber says he cannot remember the author's name, something that later histories repeat verbatim, thereby indicating Gerber as their source. In an account that potentially refers to the Geyer instruments with the "protruding sockets placed in the middle of the horn"[12] mentioned in the earlier Forkel article, Gerber proceeds to say that there were problems with the insertion of tuning-slide crooks in the early *Inventionshorns*. These problems were thought to have been corrected, in Vienna ca. 1780, by means of extending these sockets. Gerber suggests that any such refinements ca. 1780 were predated by Werner from ca. 1750.[13] The first author to state explicitly

that the artisan in Hanau was Haltenhof is Heinrich Domnich, in his *Méthode* of ca. 1807.[14]

It is thought that the design of the *cor solo* emerged from the collaboration in 1781 between Lucien-Joseph Raoux and Türrschmidt, as reported in the article on Raoux in Gerber's *Neues historisch-biographisches Lexikon* (1812–14).[15] This collaboration resulted in a distinction between the *Inventionshorn* of the time and the *cor solo*: in the new instrument the tubing crosses before reaching the tuning-slide crook. According to Gerber, Türrschmidt "made with the famous instrument maker Raoux in Paris a silver horn constructed in accordance with this new principle, an instrument he [i.e., Türrschmidt] used until his death."[16] An additional route of the *Inventionshorn* to France could be via Anton Hampel and his pupil Giovanni Punto, since Joseph Raoux made a silver instrument for Punto in either 1778 or 1779.[17]

Many early nineteenth-century sources repeat almost verbatim the origins of the instrument, following either the Gerber/Dresden/Werner story or the Ribock/Domnich/Hanau/Haltenhof story—for example, Wilhelm Schneider's "Waldhorn" article in the *Historisch-technische Beschreibung der musicalischen Instrumente* (1834).[18] Schneider's account is interesting: the basic structure and facts suggest Gerber as his source; however, he includes a drawing in the text to illustrate the crook on the *Inventionshorn* (Figure 2).


man bewirkte, daß
in die Höhe geſchol
n hat , ſteck
Ende aber umſchli
in ſich ſchiebt. D
ch ganz reine Stim

Figure 2: Illustration in Wilhelm Schneider, *Historisch-technische Beschreibung der musicalischen Instrumente* (Leipzig: Theodor Hennings, 1834), s.v. "Waldhorn." Source: http://reader.digitale-sammlungen.de/de/fs1/object/display/bsb10599455_00054.html

Early illustrations of *Inventionshorns/cors-solo* in pedagogical texts.

The pictorial evidence in late eighteenth- and early nineteenth-century methods raises some questions. More often than not it is either an *Inventionshorn* or *cor solo* that is depicted rather than the orchestral instrument, but a distinction between the orchestral horn and the other two instruments is lacking from most sources.

Both Punto's *Étude ou Exercice Journalier* (ca. 1793–1801)[19] and his "perfected" version of Hampel's *Seule et Vraie Méthode*,[20] published around 1798, include images of horns with stumpy tuning slides. In the case of the latter source, this looks like an early *Inventionshorn*, as the tubing does not cross, while with the former, the instrument illustrated could be in the Türrschmidt *cor solo* design, as the tubing does cross (Figures 3a and 3b).[21]

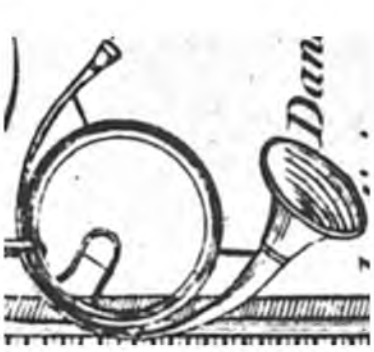

Figure 3a: Illustration in [Anton Joseph] Hampel and [Giovanni] Punto, *Seule et Vraie Méthode* (Paris: Naderman, n.d. [ca. 1798]).

Figure 3b: Illustration in [Giovanni] Punto, *Étude ou Exercice Journalier* (Paris: A La Muse du Jour, n.d. [ca. 1793–1801]).

Later German horn methods, such as Johan Heinrich Göroldt's *Ausführliche theoretisch-praktische Hornschule* (1833),[22] Carl Klotz's *Praktische Schule für das einfache und chromatische Horn* (1863),[23] and Friedrich Gumbert's *Praktische Horn-Schule* (1879),[24] depict clearly *Inventionshorns* with the non-crossed tubing. However, given that the depiction of these instruments, like the two Punto images, are in title pages or frontispieces, they could potentially be seen as decorative rather than illustrative (Figures 4a. 4b, 4c).

Figure 4a: Illustration in J. H. Göroldt, *Ausführliche theoretisch-praktische Hornschule* (Quedlinburg: J. Basse, 1833).

Figure 4b: Illustration in Klotz, *Praktische Schule für das einfache und chromatische Horn* (Offenbach: André,1863).

Figure 4c: Illustration in Friedrich Gumbert, *Praktische Horn-Schule* (Leipzig: Forberg, 1879).

The only method that seems clearly to depict what appears to be a Raoux design of a cor solo is Jacques-François Gallay's *Méthode pour le cor* (1843; Figure 5).[25] Gallay makes no mention of the particularities of the *cor solo*, other than advice on removing water from either instrument.

Figure 5: Jacques François Gallay, *Méthode pour le Cor,* op. 54 (Paris: Schonenberger, *ca.* 1845).

Focusing first on illustrations in Germanic methods, two extremely similar instruments are depicted in Joseph Fröhlich's *Vollständige Theoretisch-practische Musikschule* (1813) [26] (Figure 6a) and in Andreas Nemetz's *Hornschule* (1829; Figure 6b).[27] Note the ring on the mouthpiece, one of many details that suggests that Nemetz's image is based directly on the earlier one by Fröhlich. These seem to be of a generic *Inventionshorn/cor-solo* design, i.e., there is nothing in these images that would strongly suggest one particular maker. This is similarly the case with illustrations in Rossmann's *Horn-Schule* (1866; Figure 6c),[28] Göroldt's *Ausführliche theoretisch-praktische Hornschule* (1833; Figure 6d),[29] and Adam Wirth's *Praktische, systematisch geordnete Hornschule* (1877; Figure 6e).[30] Wirth's illustration includes the term *einfache Horn* or *cor simple*, though earlier in the text Wirth states that these terms are synonymous with "orchestral horn" and says that the instrument has crooks from B♭ alto through to B♭ basso, thereby pointing back to a defining element of the *Inventionshorn* as having the full range of crooks in contrast to the *cor solo*'s limited range.[31] Given that all these sources are Germanic, we can infer that the crossed-over pipework is not restricted to the French *cor solo* and that later German *Inventionshorns* also incorporated this design, therefore crossed-over pipework should not be seen as an identifying feature of the *cor solo*.

Figure 6a: Illustration in Franz Joseph Fröhlich, *Vollständige Theoretisch-practische Musikschule* (Bonn: Simrock, 1813).

Figure 6b: Illustration in Andreas Nemetz, *Hornschule* (Vienna: Diabelli, 1829).

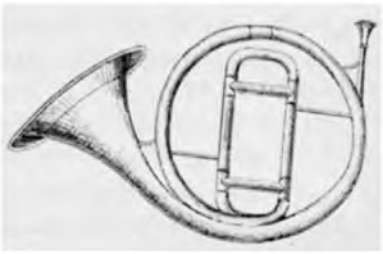

Figure 6c: Illustration in Louis Rossmann, *Horn-Schule: Kurze u. praktische Anleitung zur Erlernung des Hornes. Mit 2 Grifftabellen* (Augsburg: A. Böhm & Sohn, 1866).

Figure 6d: Illustration in J. H. Göroldt, *Ausführliche theoretisch-praktische Hornschule* (Quedlinburg: Basse, 1833).

Figure 6e: Illustration in Adam Wirth, *Praktische, systematisch geordnete Hornschule* (Offenbach: André, 1877).

A number of French pedagogical sources include a noticeably different design of instrument, one that appears to create an illusion of having the crossed tubing prior to the tuning-slide crook. These methods are Frédéric Duvernoy's *Méthode pour le Cor* (ca. 1802; Figure 7a),[32] Cam's *Méthode de Premier et Second Cor* (ca. 1827; Figure 7b),[33] Marc Antoine Jules Corret's *Petite Méthode de Cor* (ca. 1830; Figure 7c),[34] and Jean Baptiste Mengal's *Méthode de Cor* (1835; Figure 7e).[35] Göroldt's *Ausführliche theoretisch-praktische Hornschule* (1833)[36] also includes an illustration of this design of horn (Figure 7d).

Figure 7a: Illustration in Frédéric Duvernoy, *Méthode pour le cor* (Paris: A'l'imprimer du Conservatoire de Musique, 1803).

Figure 7b: lllustration in Cam, *Méthode de Premier et Second Cor* (Lyon: Arnaud, n.d. [1827?]).

Figure 7c: lllustration in Corret, *Petite Methode de Cor* (Paris, Meissonnier, 1830/1).

Figure 7d: lllustration in J. H. Göroldt, *Ausführliche theoretisch-praktische Hornschule* (Quedlinburg: Basse, 1833).

Figure 7e: Illustration in Jean-Baptiste Mengal, *Méthode de Cor* (Paris: Meissonnier, 1835).

As with Fröhlich and Nemetz, these five images are very similar to one another and as regards some elements, nearly identical. Details of both the horns and the gentlemen playing the instruments suggest that the later images are derived from the first, the influential *Méthode* by Duvernoy. Ulrich Hübner has suggested that images of Duvernoy depict instruments by the Munich maker Michael Saurle rather than Raoux.[37] If this is the case, then given the direct rather than crossed tubing, these should all be regarded as *Inventionshorns* rather than *cors solo*.

None of these methods makes any mention of the pros or cons of either design; indeed, very few commentators do. A rare example is the 1836 edition of the *Encyclopédie des gens du monde*, in which the unnamed author deems the differences "obvious," specifying only the tessitura, the *cor solo* player being required to exploit the highest range of the instrument more frequently than the orchestral player.[38] This account is rather confusing, and given the tessitura of much of the French solo repertoire for horn of this period, the author may have conflated the *cor solo* player (i.e., the first in a horn section, who normally had the high notes) with the *cor solo* design. This account may touch on the *cor solo*'s stability, acoustical or psychological, across the range of the instrument, which is provided by the fixed leadpipe rather than potentially wobbly terminal crooks. This argument is explored by Dauprat in his *Méthode* (see below).

The Paris Conservatoire, the Raoux family, and the *cor-solo*

In 1797 the first cohort of Paris Conservatoire students competed for the *premier prix* in their respective instruments.[39] For the orchestral instrument award winners the prize would be an instrument, with the stipulation that it should be made by a French maker.[40] The winner of the horn prize was to receive a "horn with all the crooks," which was not the *cor d'orchestre*, the terminally-crooked instrument with the full complement of crooks, but instead, a *cor solo* by the Raoux family. The recipient of the premier prix for horn was the sixteen-year-old Louis-François Dauprat,[41] a student of Jean-Joseph Kenn,[42] and his award was a *cor solo*[43] made by Lucien-Joseph Raoux.[44] While the prize of a Raoux *cor solo* was an astoundingly generous reward, being the maker of choice for the Conservatoire would have been a desirable goal for an ambitious maker. It is well recognized that the Paris Conservatoire was in many ways a propaganda machine, and the association of maker and Conservatoire offered prestige for both parties.[45] For many years instruments by the Raoux family have been regarded as exemplars of high quality. Their association with establishments such as the Paris Conservatoire helped to cement this reputation. Could Raoux's reputation have been different had another French maker, such as former Raoux employee Jean-François Corméry, been appointed as maker to the Conservatoire?

Lucien-Joseph Raoux had worked alongside his father, Joseph Raoux,[46] from 1776[47] and therefore is likely to have been present in 1781 when Türrschmidt was having his instrument with the crossed tubing built.[48] The next generation of Raoux makers had a similar handover period: Lucien-Joseph Raoux's son Marcel-Auguste states in his 1865 testament that he had worked for forty-five years in the family business, thus indicating that he was making instruments from the 1820s onward.[49]

The links between the Raouxs, the Conservatoire, and ultimately Dauprat were multifaceted (see Figure 8). Jean-Joseph Kenn, the young Dauprat's teacher, was one of the first teachers at the Conservatoire. Kenn was also Lucien-Joseph Raoux's brother-in-law, having married Raoux's sister Marie Angélique[50] in 1788.[51] Even after her death, and despite his remarriage, Kenn maintained close ties with the Raoux family, residing until his death[52] at Fontainebleau in a house belonging to the Raouxs. Similarly, the relationship between Dauprat and the Raouxs continued to be close; for instance, Dauprat, given his authority on the instrument, was the expert witness on the value of Marcel-Auguste's stock on the occasion of Marcel-Auguste's separation from his wife in 1836.[53]

We can therefore demonstrate that there was a strong relationship between the Conservatoire, through Kenn and then Dauprat himself, and the Raoux family. Generations of prizewinners graduated with Raoux *cors solo*, including the brothers Martin Joseph[54] and Jean-Baptiste Mengal,[55] Joseph-Emile Meifred,[56] and Jacques-François Gallay,[57] thereby cementing the relationship and also reiterating the link between the Raoux *cor solo* and elite horn players. The importance and significance of these horns are articulated in letters to the Conservatoire from Dauprat[58] on his

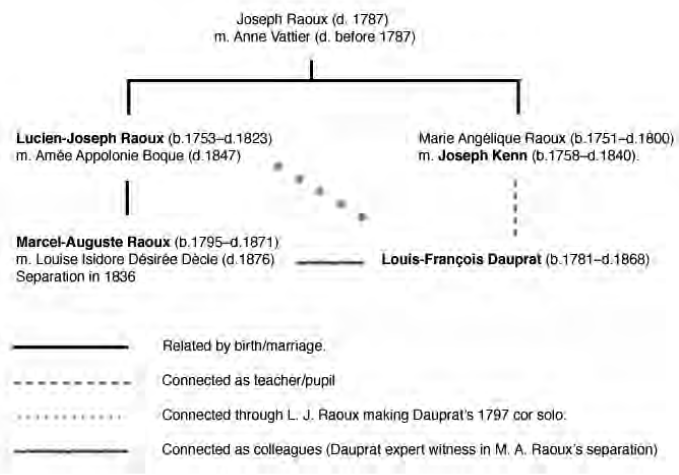

Figure 8: Connections between the Lucien-Joseph Raoux, Marcel-Auguste Raoux, Joseph Kenn, and Louis-François Dauprat.

retirement and from Gallay's daughter on the death of her father,[59] detailing the donation of these instruments to the Conservatoire's collection. Dauprat wrote in 1852 that he had never previously believed he would part company with the instrument that he called the "crown of his youth," but he would "blush to see her decorate a merchant's stall," hence taking the precaution of giving the instrument to the Conservatoire where, he hoped, his young future colleagues would see the care that he had taken with the instrument, and that he had not "tampered" with it in any way, and therefore they would emulate his approach.[60] The "tampering" to which Dauprat referred could be the practice of adapting *cors solo* to take *sauterelle* valve-blocks.[61]

This relationship between the Conservatoire and the Raouxs was first diminished due to the loss of Raoux's *brevetés* in the 1830 revolution.[62] Previously the Raouxs had been able to count on these licenses that enabled them to style themselves makers to the king, the Académie Royale de Musique, the Conservatoire, etc.[63] The 1830 revolution disrupted Raoux's monopoly. The importance of the *cor solo* model began to wane in mid-century as makers in France produced more instruments with the military market in mind.[64] Fewer *cor solo* instruments were produced in the middle of the nineteenth century, although occasionally makers elsewhere produced them, such as the Distin & Co. *cor solo*, produced in 1871 for the military market.[65]

The Raouxs made instruments for the Conservatoire and for theaters and opera houses. Horn players and horn students would have had at their disposal *cors d'orchestres*, instruments with full sets of crooks, from the institutions where they worked or

studied.[66] The *cor solo*, with its small range of crooks, was realistically of use only for this small group of elite horn players, and this may explain why the prizewinners were awarded *cors solo* rather than *cors d'orchestres*.

The *cor solo* is a limited instrument. In his *Méthode*, Dauprat outlined the advantages of this design as giving the instrument more "grace" and making it easier to hold, the disadvantages being that the practicalities of the tuning-slide crook meant that "one would risk straining the slides in changing the crooks often and hurriedly" in an orchestral situation. A compromise model used tuning-slide crooks with the fixed mouthpipe for the lower tonalities and short "plug-in" crooks that fitted into the body of the horn as tuning-slides, but had their own mouthpiece receivers for the higher tonalities.[67] Dauprat praised the solo crooks of the *cor solo*, but he identified the problem with the high crooks available for these compromise instruments, as they "divide the instrument in half, and render one of the two slides useless, as well as the tubes attached to it; these keys present a second leadpipe that hampers the performer in the holding of his instrument."[68] As Dauprat notes, the addition of high crooks to the *cor solo*, which in effect is done by putting a terminal crook on the tuning slide, creates an instrument that, for those keys, operates as a *cor d'orchestre*.

Dauprat's concerns regarding the restriction in the speed with which a player can change crooks point to another serious limitation of the *cor solo* and *Inventionshorn* designs. Curiously, this concern appears to be in conflict with the views expressed by Gerber a generation earlier. Gerber remarked on the "ease with which orchestral players, equipped with good *Inventionshorns*, can now change key in the space of a few bars' rest."[69] Gerber compares "true, improved *Inventionshorns*" with the "so-called *Inventionshorns* for all the keys," which he warned were being sold in Leipzig with "old coiled crooks that fit into the mouthpiece."[70] Given that changing terminal crooks is faster than changing tuning-slide crooks, it may be that the "so-called *Inventionshorns*" Gerber refers to were in fact the more common master-crook-and-coupler system of the period, which was more cumbersome and time-consuming for crook changes.

Gerber does go on to comment that "all of these improvements have been devised specifically for the betterment of those horns which accompany in the orchestra. For solo playing and duets the virtuoso uses only the simple horn without crooks," i.e., a fixed-pitch instrument. This comment, that virtuosos prefer fixed-pitch instruments, touches once more upon the key element of the *Inventionshorn/cor solo* design that ensured its prowess as the soloist's instrument, that of the fixed leadpipe and the stability (psychological or acoustical) that it gives. Dauprat's earlier criticism of the higher crooks on the compromise instruments is based on the fact that on these instruments the "plug-in" high crooks are created by putting the crook, complete with leadpipe, on the tuning slide of the instrument. This negates the strength of the design provided by the fixed leadpipe and the alternative tuning-slide crooks. The high crooks on a compromise horn really have no advantage over the terminal high crooks on an orchestral horn.

Differences in playing characteristics between the *cor solo* and *cor d'orchestre*

In order to assess the differences in playing characteristics between the *cor solo* and the *cor d'orchestre*, the authors compared bore profiles. The bore profile is generally acknowledged to be the design parameter that most strongly influences the sound, intonation, and playing characteristics of a brass instrument.[71] To this end, the bore profiles of more than fifty instruments were measured, using a series of rod probe gauges and calipers.[72] These instruments were mostly from the late eighteenth and early nineteenth centuries, and with an emphasis on *cor solo*, *Inventionshorns*, and *cors d'orchestre*. As described above, Lucien-Joseph Raoux and Marcel-Auguste Raoux are the makers most closely linked with the development and manufacture of the *cor solo*, and it is not surprising that most of the instruments measured here were made by them: ten are attributed to Lucien-Joseph Raoux and fifteen to Marcel-Auguste Raoux.

The newer instruments by Marcel-Auguste Raoux are, in general, in better condition and generally present little variation in bore dimensions between instruments. The average bore profile of the M.-A. Raoux *cor solo* instruments was used to form a basis for comparison with the other instruments, using bore-profile comparison software developed at the University of Edinburgh.[73] The software interpolates the measured bore profiles (to increments of 1 mm) and then calculates a relative root-mean-square deviation (rRMS) from the baseline bore profile (in this case, the average of the M.-A. Raoux *cor solo* horns), using Equation 1, where ρ_{target} is the bore diameter of the target horn at a given point, ρ_{bp} is the bore diameter of the comparator horn, and N is the number of data points.

$$rRMS = \sqrt{\frac{1}{N}\sum\left(\frac{\rho_{bp} - \rho_{target}}{\rho_{target}}\right)^2}$$

Equation 1

For this study, the first 20 mm of the bell of each instrument was not used. This is because the rim of the bell is prone to damage (and even an expert repair will result in some plastic deformation, and hence a change in the original profile). The rim of the bell of a horn is also more prone to manufacturing variation than more gently tapering sections. Typically, these horns have a maximum bell diameter of 280 mm. Omitting the first 20 mm means the starting point for comparison is where the internal diameter of the bell is approximately 200 mm. The length of the bell and spout section then used for comparison is 1000 mm.

Isolating all of the instruments attributed to Lucien-Joseph Raoux and Marcel-Auguste Raoux, including all *Inventionshorns*, *cors solo*, and *cors d'orchestre*, and comparing these with the baseline profile, gives an indicator of variance in M.-A. Raoux

horns and how much these differ from those of L.-J. Raoux, as shown in Figure 9. For French instruments the term *Inventionshorn* is used here to indicate compromise instruments with fixed mouthpipe and alternative tuning-slides for the lower crookings and "plug-in" crooks with integral mouthpipes for the high crookings.

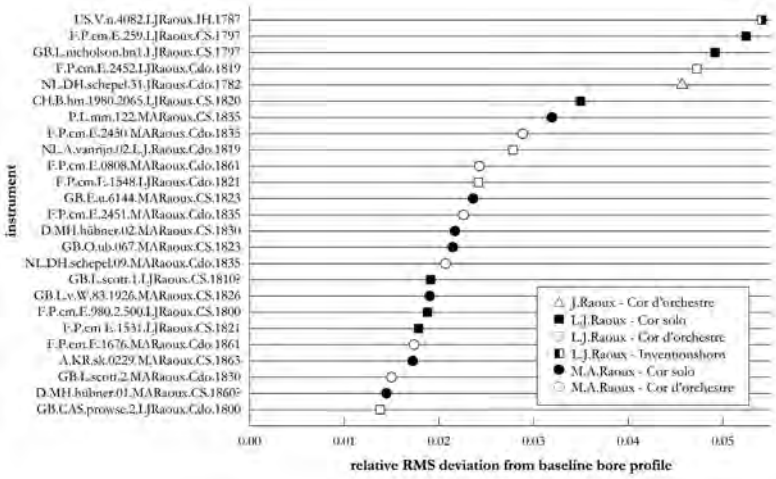

Figure 9: Relative RMS deviation from the baseline bore profile for the bells of M.-A. Raoux and L.-J. Raoux horns measured in this study, ranked in ascending order of rRMS.

Figure 9 also includes a date of manufacture, known or estimated (where a range is known, the estimated date is mid-range). From this, we can see that there appears to be no obvious distinction between type of instrument (*Inventionshorn*, *cor solo*, or *cor d'orchestre*), or between makers (Lucien-Joseph or Marcel-Auguste). However, there does appear to be a difference between those made in the eighteenth century and those made in the nineteenth century. Not surprisingly, the nineteenth-century instruments conform more closely with the baseline bore profile.

Notwithstanding that these are old instruments, and that some will have been damaged and repaired, resulting in bore profiles that have changed somewhat from when they were new, thereby introducing some noise in the data, the inference from Figure 9 is that the older L.-J. Raoux instruments are likely to have come from a different mandrel than those instruments made in the nineteenth century. It is known that Lucien-Joseph and Marcel-Auguste worked in the same workshop,[74] and it is highly likely that they used the same bell mandrel. It is common modern practice for instrument makers to outsource parts for their instruments, such as bells, from third-party suppliers. This is not a recent phenomenon: Lisa Norman provides evidence that in London in the mid-eighteenth century instrument makers Nicholas Winkings and John Christopher Hofmaster were producing bells from the same mandrel, as were William Sandbach, Thomas Key, and Smith & Sons in the early nineteenth century.[75]

It is likely that similar practices occurred in Paris, and it would not be surprising to see father and son sharing tools and/or manufactured components.

Adding a range of other *cors solo*, *Inventionshorns*, *cors d'orchestres*, and valve horns to the Raoux horns, and making a similar comparison, we can see from Figure 10 that there are no obvious differences between types.

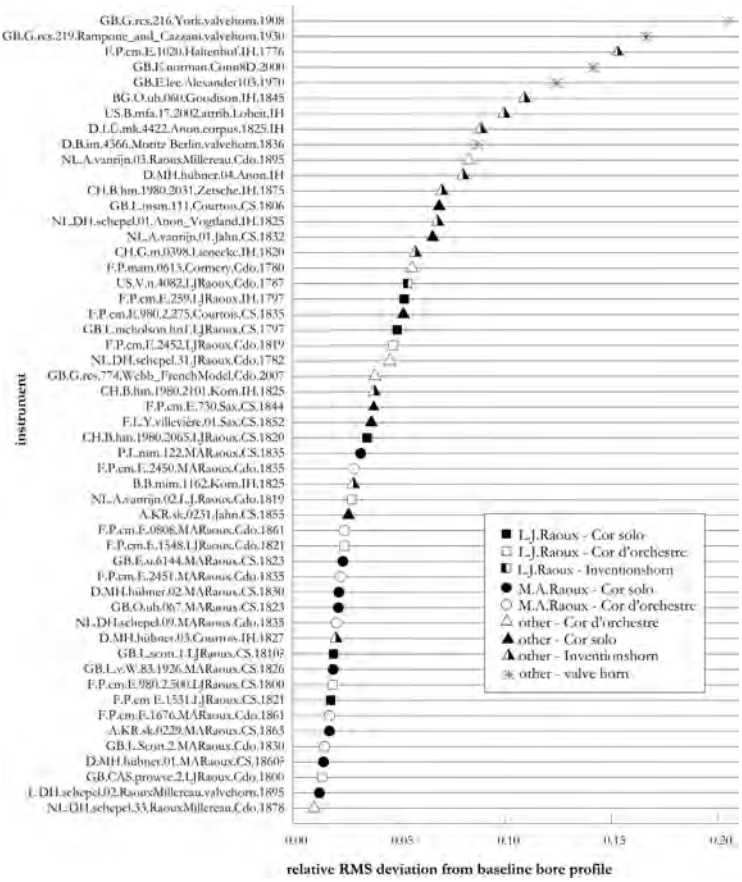

Figure 10: Relative RMS deviation from the baseline bore profile for all horns measured in this study, ranked in ascending order of rRMS.

The mouthpipe also has a significant effect on the playing characteristics of the instrument. A comparable analysis to that carried out for the bell is complicated by the fact that the terminal crooks of *cors d'orchestre* are often swapped and changed by players to match their preferences, and hence the provenance of these crooks is often less clear than for the bell of the instrument. Figure 11 shows that there are no discernible trends.

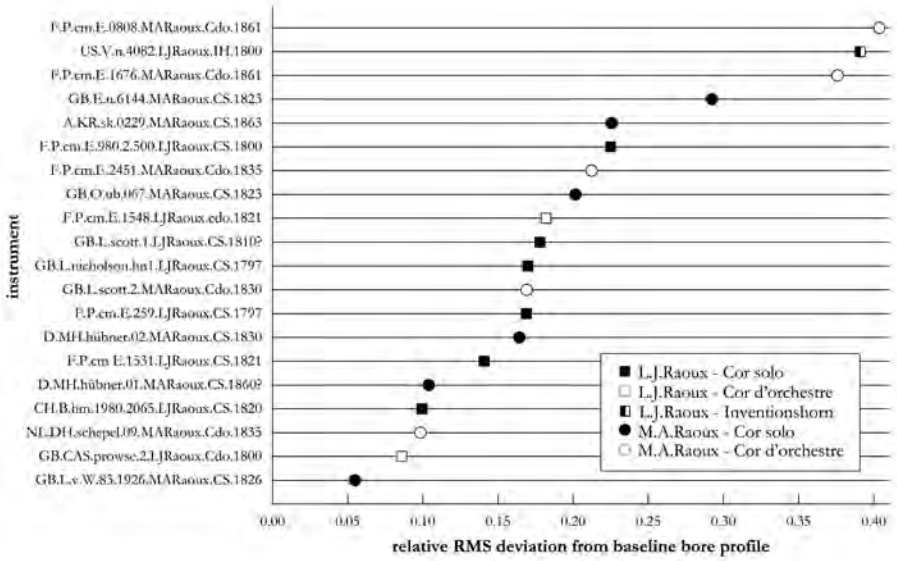

Figure 11: Relative RMS deviation from the baseline bore profile for the mouthpipes of all M.-A. Raoux and L.-J. Raoux horns measured in this study, ranked in ascending order of RMS.

A view complementary to the comparisons of long sections of bore profile is given by examination of the shape of the bell in the immediate area where the hand is placed. Robert Pyle investigated horns with both narrow and wide bell throats and confirmed players' experience that narrow bells are more sensitive to hand-stopping in that less hand movement is needed to achieve a given lowering of pitch.[76] Bell throats can be characterized by the angle between the bell wall and the bell axis at the point where the diameter is 100 mm, typically where a player's hand is placed in the bell. This angle has been determined by fitting a curve (a Bessel horn) to the region of the bell with diameters between 121.5 and 81.45 mm and calculating the bell wall angle where the diameter is 100 mm: this angle ranges from around 20° (wide bell throat) to around 30° (narrow bell throat). Table 1 gives this bell wall angle for the instruments measured in this study; Figure 12 is a plot of bell wall angle against date for all the Raoux horns and Figure 13 is a plot for all the horns.

Table 1: Horns ranked by bell wall angle: the angle (in degrees) between the bell wall and the bell axis at the point where the diameter is 100 mm. (See Appendix for keys to museum sigla)

		Instrument	angle
A.KR.sk	229	Cor solo (late M.-A. Raoux or early J. C. Labbaye, Paris, ca. 1863)	29.3
NL.DH.schepel	2	Valve horn, Military model (Raoux/Millereau, Paris, 1878–1911, ca. 1895)	28.2
F.P.cm	E.0808	Cor d'orchestre (M.-A. Raoux, Paris, 1852–70, ca. 1861)	28.0
F.P.cm	E.2450	Cor d'orchestre (M.-A. Raoux, Paris, 1821–48, ca. 1835)	27.9
NL.DH.schepel	33	Cor d'orchestre (Raoux/Millereau, Paris, p. 1878)	27.6
NL.A.vanrijn	2	Cor d'orchestre (L.-J. Raoux, Paris, 1814–23, ca. 1819)	27.6
F.P.cm	E.980.2.500	Cor solo (L.-J. Raoux, Paris, ca. 1800)	27.6
NL.A.vanrijn	3	Cor d'orchestre (Raoux/Millereau, Paris, 1878–911, ca. 1895)	27.4
D.MH.hübner	2	Cor solo (M.-A. Raoux, Paris, ca. 1830)	27.4
F.P.cm	1676	Cor d'orchestre (M.-A. Raoux, Paris, 1852–70, ca. 1861)	27.3
F.P.cm	E.1531	Cor solo (L.-J. Raoux, Paris, 1821)	27.1
GB.E.u	(6144)	Cor solo (M.-A. Raoux, Paris, 1823)	27.1
GB.O.ub	67	Cor solo (M.-A. Raoux, Paris, 1823)	26.9
GB.L.scott	2	Cor d'orchestre (M.-A. Raoux, Paris, 1821–48, ca. 1830)	26.7
F.P.cm	E.1548	Cor d'orchestre (L.-J. Raoux, Paris, 1821)	26.6
D.MH.hübner	1	Cor solo (M.-A. Raoux, Paris, ca. 1860)	26.6
GB.L.v	W.83.1926	Cor solo (M.-A. Raoux, Paris, 1826)	26.5
NL.A.vanrijn	1	Cor solo (Jahn, Paris ca. 1832)	26.3
F.P.cm	E.2451	Cor d'orchestre (M.-A. Raoux, Paris, 1835)	26.2
NL.DH.schepel	9	Cor d'orchestre (M.-A. Raoux, Paris, 1821–48, ca. 1835)	26.2
P.L.mm	122	Cor solo (M.-A. Raoux, Paris, 1835?)	26.1
A.KR.sk	231	Cor solo (Jahn, Paris, ca. 1850–60, ca. 1855)	25.8
F.P.cm	E.730	Cor solo (Ad. Sax, Paris, 1844)	25.7
GB.L.scott	1	Cor solo (L.-J. Raoux, Paris, ca. 1810)	25.1

F.P.cm	E.2452	Cor d'orchestre (L.-J. Raoux, Paris, 1814–23, ca. 1819)	25.1
GB.G.rcs	774	Hand horn, French model (John Webb, London, 2007)	25.1
US.B.mfa	17.2002	Inventionshorn (formerly attributed to Lobeit)	24.8
GB.G.rcs	219	Valve horn (Rampone & Cazzani, Milan, ca. 1930)	24.8
D.MH.hübner	3	Inventionshorn (Courtois neveu, Paris, ca. 1827)	24.7
GB.CAS.prowse	2	Cor d'orchestre (L.-J. Raoux, Paris, ca. 1800)	24.6
D.N.gnm	MIR383	Inventionshorn (Carl Gottfried Glier & Sohne, Markneukirchen, ca. 1830)	24.6
GB.L.am		Raoux cor solo (Paris, 1821), converted to valve horn	24.5
F.LY.villevière	1	Cor solo (Ad. Sax, Paris, 1852)	24.2
F.P.cm	E.980.2.275	Cor solo (Courtois frère, Paris, 1814–44, ca. 1835)	24.1
GB.L.msm	111	Cor solo (Courtois neveu, Paris, 1802–09, ca. 1806)	24.0
CH.BE.schmitt	1	Inventionshorn (Tabard, Lyon, a. 1848)	23.9
B.B.mim	1162	Inventionshorn (Philipp Ferdinand Korn, Mainz, ca. 1825)	23.9
US.V.n	4082	Inventionshorn (L.-J. Raoux, Paris, 1780-93, ca. 1787)	23.6
GB.O.ub	60	Inventionshorn (Goodison, London, ca. 1845)	23.6
D.MH.hübner	4	Inventionshorn (Germany?)	23.5
GB.L.nicholson	hn1	Cor solo (L.-J. Raoux, Paris, 1797)	23.4
CH.B.hm	1980.2031	Inventionshorn (Johann Heinrich Zetsche, Hannover, ca. 1875)	23.1
NL.DH.schepel	31	Cor d'orchestre (Joseph Raoux, Paris, 1776–92, ca. 1782)	23.0
F.P.mam	01613	Inventionshorn (Jean-François Corméry, Paris, 1776–86, ca. 1780)	23.0
CH.B.hm	1980.2101	Inventionshorn (Philipp Ferdinand Korn, Mainz, ca. 1825)	23.0
NL.DH.schepel	1	Inventionshorn (probably Vogtland, ca. 1825)	23.0
F.P.cm	E.259	Cor solo (L.-J. Raoux, Paris, 1797)	22.4
GB.L.hm	14.5.47/166	Cor d'orchestre (L.-J. Raoux, Paris, 1814)	21.9

CH.B.hm	1980.2065	Cor solo (L.-J. Raoux, Paris, 1820)	21.8
F.P.cm	E.1020	Inventionshorn (Haltenhof, Hanau, 1776)	21.8
CH.G.m	398	Inventionshorn (Johann Conrad Lienecke, Leipzig, ca. 1820)	21.1
D.N.gnm	MIR326	Inventionshorn (Probably Vogtland, early 19th century)	20.9
GB.G.rcs	216	Valve horn (York, Grand Rapids, ca. 1908)	19.4

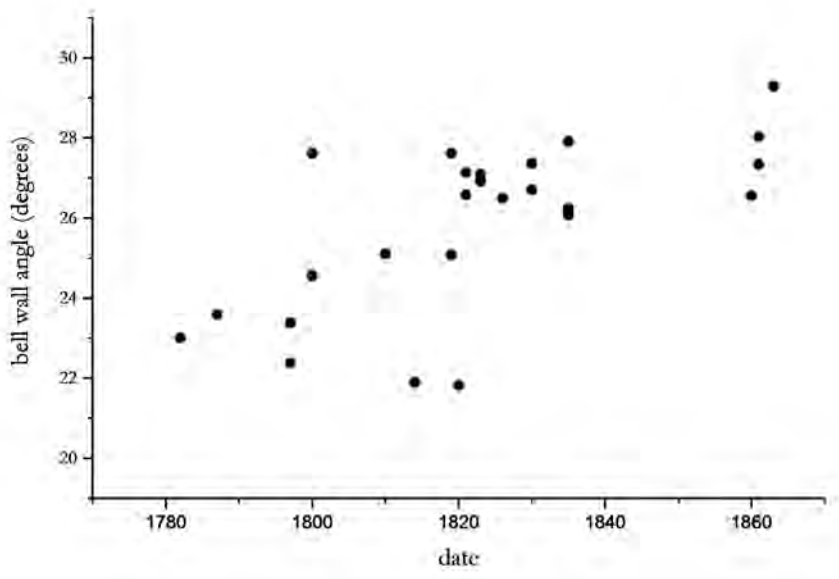

Figure 12: Scatter plot of bell wall angle against date for Raoux horns measured in this study.

The results are consistent with those from the bore comparisons above: there is no distinction between the Raoux *cor solo*, *cor d'orchestre*, and *Inventionshorn*, while there is a trend towards narrower bell throats from the eighteenth century into and through the nineteenth. The relatively narrow bell throats typical of French models and wide throats of German models confirm Pyle's findings.

From the analysis of the bore profiles it would seem that there is no significant difference between the *cor solo* and the *cor d'orchestre*, and yet players are adamant that there is a difference. Determining the source of the difference in playing characteristics, if not the bore profile, is more difficult. The fixed mouthpipe of the *cor solo* has a number of advantages: the ergonomic relationship between mouthpiece and left

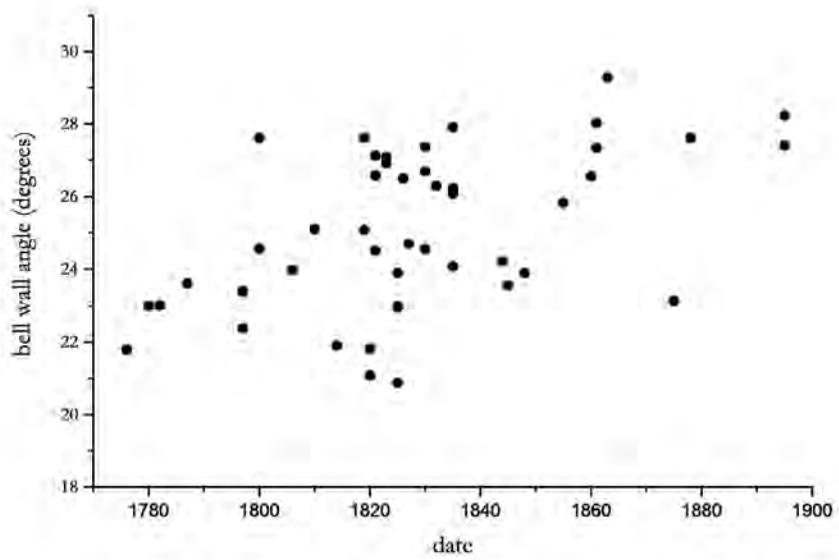

Figure 13: Scatter plot of bell wall angle against date for all horns measured in this study.

and right hands is consistent and can be optimized. The tenon-and-socket joint of a terminal crook is not dissimilar to the tapered stem of a mouthpiece inserted into the mouthpiece receiver. However, the additional mechanical leverage between the player's lips and the socket may provide a small amount of unwelcome movement in the joint, which is not present in the fixed mouthpipe of the *cor solo*. The tenon-and-socket joint is also more prone to leaks, which would have a detrimental effect on the way the instrument plays.

Feedback to the player's lips from structural vibrations has also been cited as a possible factor in determining playing characteristics.[77] The feedback mechanism may be affected by the wrap of the instrument, braces and stays, etc. In this respect the *cor solo* and *cor d'orchestre* have significant differences.

Players' perspectives

Given its strengths, the *cor solo* can be viewed as a useful instrument, but also as a curiosity, given that no other instrument of this period comes in two such distinct designs. One, the *cor solo*, for the soloist and solo repertoire, being an instrument that would not be useable in the orchestra. The other, the *cor d'orchestre*, intended for the orchestral musician and orchestral repertoire, is still perfectly viable for use in solo repertoire.

If the *cor d'orchestre* is perfectly useable for solo repertoire, what are the advantages of the *cor solo* for such repertoire? Seven historic horn experts were surveyed regarding

their experience and perceptions of playing *cors solo*.[78] It is indicative of the restrictive nature of these instruments that a further number of active practitioners in this field responded, stating that they had never pursued the idea of owning a *cor solo*, given that the cost of such an instrument versus the frequency that it could be used makes it an unwise investment. One respondent previously owned a *cor solo*; however, he felt unable to justify keeping the instrument and therefore sold it. This demonstrates how even very active historic horn practitioners will find few opportunities to play such instruments. This question of "cost per play" is also reflected in practitioners often having gained experience of the *cor solo* thanks to the loan of instruments from museums or private collections.[79]

All respondents identified solo and chamber repertoire as the most relevant repertoire for the instrument, with most believing that the instrument is inappropriate for orchestral works. Most suggested specifically French and specifically nineteenth-century repertoire as the most suitable repertoire, though Mozart's concerti; Beethoven's Sonata, op. 17; the Ries Sonata, op. 34; and the Brahms Trio, op.40 were also suggested.

While many respondents mentioned foibles of particular instruments or crooks (for example, "[the] E♭ [crook] didn't sit right (intonation and resistance were less clear than in E),"[80] the stability, smoothness and evenness of the instrument, and the ease of control for the performer were frequently reiterated in responses. Practitioners identified the main reason for these features as the fixed mouthpipe, which offers "no obstacle at the beginning of the horn"[81] in comparison to the "wobble-factor"[82] encountered with terminal-crooked horns. The evenness was not always viewed as a wholly positive feature, with one respondent questioning whether the timbral differences between the crooks were less pronounced on the *cor solo* than on terminally crooked instruments. The physicality of the instrument was seen as a distinct advantage of the *cor solo*. The instrument was perceived as lighter than terminally crooked horns,[83] that it felt good to hold,[84] and, a most beautiful response, that it gave "the sensation of being in touch with the heart of the instrument."[85]

The experience of one of the present authors (Anneke Scott) is that they are very flexible and nimble instruments. She has been fortunate to have gained good knowledge as a performer on two such instruments, the Bate Collection's Marcel-Auguste Raoux[86] and an earlier Lucien-Joseph Raoux instrument that she now owns. She recounts that the Bate instrument feels speedier, quick-silver, and alert, but never shrill, while the earlier instrument hints at a different aesthetic, not necessarily darker in timbre but more mellow and compact. In comparison with *cors d'orchestre*, such as Scott's Marcel-Auguste Raoux *cor d'orchestre*, they feel very stable to play, an advantage of the fixed leadpipe in comparison to the (admittedly looser with age) crooks of the *cor d'orchestre* or even to modern copies. These playing capabilities are advantageous in the virtuosic playing that marks much of the nineteenth-century French repertoire.

The present survey highlights the fact that there is no significant difference in terms of bore profile between the *cor solo* and the *cor d'orchestre*. Given that the *cor solo*, with its small range of crooks, could be viewed as a more limiting instrument

in comparison to the *cor d'orchestre*, why would a player choose the *cor solo* over the *cor d'orchestre*? The success of the *cor solo* design with horn players may well be due physical factors, such as the stability of the leadpipe, the lightness of the instrument, the weight balance, or its immediacy. It may also be in part due to its perception as a prestige instrument, given that it was awarded to winners of the coveted *premier prix*, the small number of musicians who have the opportunity to own one, and (due to the nature of the repertoire the instrument best suits) the frequency and occasion in which such instruments are played all help promote the image of the instrument as "elite."

Appendix

List of instruments included in this study. The numbers given to privately owned instruments are solely for the organization of this study.

Siglum	Inventory number	Instrument
		INVENTIONSHORNS
CH.B.hm	1980.2101	Inventionshorn (Philipp Ferdinand Korn, Mainz, ca. 1825)
B.B.mim	1162	Inventionshorn (Philipp Ferdinand Korn, Mainz, ca. 1825)
CH.B.hm	1980.2031	Inventionshorn (Johann Heinrich Zetsche, Hannover, ca. 1875)
GB.O.ub	60	Inventionshorn (Goodison, London, ca. 1845)
D.MH.hübner	4	Inventionshorn (Germany?)
CH.G.m	398	Inventionshorn (Johann Conrad Lienecke, Leipzig, ca. 1820) with nine tuning-slide crooks from B♭ alto to B♭ basso
D.N.gnm	MIR326	Inventionshorn (Probably Vogtland, early 19th century)
US.B.mfa	17.2002	Inventionshorn (formerly attributed to Lobeit)
D.N.gnm	MIR383	Inventionshorn (Carl Gottfried Glier & Sohne, Markneukirchen, ca. 1830)
D.N.gnm	MIR421	Inventionshorn (Carl Gottfried Glier & Sohne, Markneukirchen, ca. 1830)
		HORNS WITH PLUG-IN HIGH CROOKS
F.P.cm	E.1020	Inventionshorn (Haltenhof, Hanau, 1776)
NL.DH.schepel	1	Inventionshorn (Probably Vogtland, ca. 1825), plug-in crooks for B♭ alto and A; tuning-slide crooks for G to B♭ basso

F.P.mam	01613	Inventionshorn (Jean-François Corméry, Paris, 1776–86, ca. 1780) plug-in crooks from C alto to F; tuning-slide crooks from E to B♭ basso
US.V.n	4082	Inventionshorn (L.-J. Raoux, Paris, 1780–93, ca. 1787) plug-in crooks for B♭ alto to G; tuning-slide crooks for F to B♭ basso
D.MH.hübner	3	Inventionshorn (Courtois neveu, Paris, ca. 1827) plug-in crooks for B♭ alto and A; tuning-slide crooks for G to B♭ basso
CH.BE.schmitt	1	Inventionshorn (Tabard, Lyon, a. 1848) postulated plug-in crooks for B♭ alto to G; tuning-slide crooks for F to B♭ basso
		J. RAOUX
NL.DH.schepel	31	Cor d'orchestre (J. Raoux, Paris, 1776–92, ca. 1782)
		L.-J. RAOUX
F.P.cm	E.259	Cor solo (L.-J. Raoux, Paris, 1797) [ex-Dauprat]
GB.L.nicholson	hn1	Cor solo (L.-J. Raoux, Paris, 1797)
GB.L.scott	1	Cor solo (L.-J. Raoux, Paris, ca. 1810)
CH.B.hm	1980.2065	Cor solo (L.-J. Raoux, Paris, 1820) [ex- J. Mengal]
GB.CAS.prowse	2	Cor d'orchestre (L.-J. Raoux, Paris, ca. 1800)
F.P.cm	E.2452	Cor d'orchestre (L.-J. Raoux, Paris, 1814–23, ca. 1819)
NL.A.vanrijn	2	Cor d'orchestre (L.-J. Raoux, Paris, 1814–23, ca. 1819)
F.P.cm	E.1548	Cor d'orchestre (L.-J. Raoux, Paris, 1821)
F.P.cm	E.980.2.500	Cor solo (L.-J. Raoux, Paris, ca. 1800)
F.P.cm	E.1531	Cor solo (L.-J. Raoux, Paris, 1821) [ex-Gallay]
		M.-A. RAOUX
GB.E.u	(6144)	Cor solo (M.-A. Raoux, Paris, 1823)
GB.O.ub	67	Cor solo (M.-A. Raoux, Paris, 1823)
GB.L.v	W.83.1926	Cor solo (M.-A. Raoux, Paris, 1826) [ex-Puzzi]
D.MH.hübner	2	Cor solo, left hand to bell (M.-A. Raoux, Paris, ca. 1830)
P.L.mm	122	Cor solo (M.-A. Raoux, Paris, 1835?)
D.MH.hübner	1	Cor solo, right hand to bell (M.-A. Raoux, Paris, ca. 1860)
A.KR.sk	229	Cor solo (late M.-A. Raoux or early J. C. Labbaye, Paris, ca. 1863)
GB.L.scott	2	Cor d'orchestre (M.-A. Raoux, Paris, 1821–48, ca. 1830)
NL.DH.schepel	9	Cor d'orchestre (M.-A. Raoux, Paris, 1821–48, ca. 1835)

F.P.cm	E.2450	Cor d'orchestre (M.-A. Raoux, Paris, 1821–48, ca. 1835)
F.P.cm	E.2451	Cor d'orchestre (M.-A. Raoux, Paris, 1835)
F.P.cm	E.0808	Cor d'orchestre (M.-A. Raoux, Paris, 1852–70, ca. 1861)
F.P.cm	1676	Cor d'orchestre (M.-A. Raoux, Paris, 1852–70, ca. 1861)
		MILLEREAU
NL.A.vanrijn	3	Cor d'orchestre (Raoux/Millereau, Paris, 1878–1911, ca. 1895)
NL.DH.schepel	33	Cor d'orchestre (Raoux/Millereau, Paris, p. 1878)
NL.DH.schepel	2	Valve horn, Military model (Raoux/Millereau, Paris, 1878–1911, ca. 1895)
		COURTOIS
GB.L.msm	111	Cor solo (Courtois neveu, Paris, 1802–09, ca. 1806)
F.P.cm	E.980.2.275	Cor solo (Courtois frère, Paris, 1814–44, ca. 1835)
		JAHN
NL.A.vanrijn	1	Cor solo (Jahn, Paris ca. 1832)
A.KR.sk	231	Cor solo (Jahn, Paris 1850–60, ca. 1855)
		SAX
F.P.cm	E.730	Cor solo (Ad. Sax, Paris, 1844) [ex-Vivier]
F.LY.villevière	1	Cor solo (Ad. Sax, Paris, 1852)
		ALTERED
GB.L.am	2003.2787	Raoux cor solo (Paris, 1821), converted to valve horn
GB.L.hm	14.5.47/166	Cor d'orchestre (L.-J. Raoux, Paris, 1814), converted to valve horn [ex- Puzzi]
		OTHERS
GB.G.rcs	774	Hand horn, French model (John Webb, London, 2007)
GB.G.rcs	216	Valve horn (York, Grand Rapids, ca. 1908)
GB.G.rcs	219	Valve horn (Rampone & Cazzani, Milan, ca. 1930)
GB.E.norman	LN8D	Double horn, 8D model (Conn, Elkhart, 2000)
GB.E.lee	1	Double horn, 103 model (Alexander, Mainz, 1970)
D.LÜ.mk	4422	Inventionshorn (anon., ca. 1825)
D.B.im	4366	Valve horn (Moritz, Berlin, ca. 1836)

Siglum	Collection
A.KR.sk	Schloss Kremsegg, Kremsmünster (Louis Stout collection), Austria
B.B.mim	Musée des Instruments de Musique, Brussels, Belgium
CH.B.hm	Musikmuseum, Historisches Museum Basel, Switzerland
CH.BE.schmitt	Christian Schmitt, Bern, Switzerland
CH.G.m	Musée d'Art et d'Histoire, Geneva, Switzerland
D.B.im	Musikinstrumenten Museum, Staatliches Institut für Musikforschung, Berlin, Germany
D.LÜ.mk	Museum für Kunst und Kulturgeschichte der Hansestadt Lübeck, Germany
D.MH.hübner	Ulrich Hübner, Mannheim, Germany
D.N.gnm	Germanisches Nationalmuseum, Nuremberg, Germany
F.LY.villevière	Eric Villevière, Lyon, France
F.P.cm	Musée de la musique, Philharmonie de Paris, France
F.P.mam	Museum of the Conservatoire National des Arts et Métiers, Paris, France
GB.CAS.prows	Martin Prowse, Castle Douglas, UK
GB.E.lee	Graeme Lee, Edinburgh, UK
GB.E.norman	Lisa Norman, Edinburgh, UK
GB.E.u	Edinburgh University Collection of Historic Musical Instruments, UK
GB.G.rcs	Royal Conservatoire of Scotland, Glasgow, UK
GB.L.am	Royal Academy of Music, London, UK
GB.L.hm	Horniman Museum, London, UK
GB.L.msm	Museum of Army Music, Kneller Hall, London, UK
GB.L.nicholson	Linda Nicholson, London, UK
GB.L.scott	Anneke Scott, London, UK
GB.L.v	Victoria & Albert Museum, London, UK
GB.O.ub	Bate Collection, University of Oxford, UK
NL.A.vanrijn	Marianne van Rijn, Amsterdam, Netherlands
NL.DH.schepel	Louise Schepel, Voorburg, Netherlands
P.L.mm	Museu da Música, Lisbon, Portugal
US.B.mfa	Museum of Fine Arts, Boston, USA
US.V.n	National Music Museum, Vermillion, USA

Addendum

Since completing the article the authors have had the opportunity to examine two further cors solo, both by Courtois frère, in the Museo Degli Strumenti Musicali, Galleria Dell'Accademia S Cecilia, Rome (I.R.an 71.1) and in the Conservatorio di Musica San Pietro a Majella, Naples (I.N.c 5.213). The Rome instrument dates from 1803–12 and the Naples from after 1812. The bore profile comparison software indicates that their relative RMS deviations from the baseline Raoux profile are 0.072 (Rome) and 0.047 (Naples). Both have a bell wall angle of 24.8°. These two horns by Courtois frère are fairly similar to the other Courtois family *cors solo* represented in Figure 1, which together show a small but significant deviation from the Raoux profile. Our thanks for Massimo Monti and Luigi Sisto respectively for facilitating this further study.

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NOTES

[1] Ulrich Hübner and Renato Meucci have both contributed informative discussions on these points.

[2] First known usage appears to be Louis-François Dauprat, *Méthode de cor alto et cor basse* (Paris: Zetter, 1824), 4.

[3] Johann Nepomuk Forkel, "Blechinstrumente, als: Hörner, Trompeten, Posaunen" in *Musikalischer Allmanach für Deutschland* (Leipzig: Schwickert, 1782), 205.

[4] Thought to mean Geyer, who flourished mid eighteenth-century Vienna. *The New Langwill Index*, ed. William Waterhouse (London: Bingham, 1993), 134.

[5] Ernst Ludwig Gerber, *Neues historisch-biographisches Lexikon der Tonkünstler*, 4 vols. (Leipzig: Kühnel, 1812–14).

[6] Gerber, *Neues historisch-biographisches Lexikon*, s.v. "Hampel, Antoine Joseph."

[7] Carl Türrschmidt, b. 24 February 1754, d. 1 November 1797, *cor basso* player in a famous duo with *cor alto* player Johann Palsa. See Gerber, s.v. "Türrschmidt, Carl."

[8] Ibid. "Unter diesen war auch er, dem ich nicht nur die Nachricht von seiner hier verzeichnet talentvollen Familie, sondern noch außerdem ganze, geschriebene Bogen, voll merkwürdiger Notizen von deutschen und französischen Meistern, zu danken hatte."

[9] Renato Meucci and Gabriele Rocchetti, *The Horn* (New Haven: Yale University Press, forthcoming).

[10] Justus Johannes Heinrich Ribock, "Auszüge aus Briefen, Nachrichten, Todesfalle" in *Magazin der Musik* 2, no. 1 (9 July 1784): 8–10.

[11] Gerber, *Historisch-biographisches Lexicon der Tonkünstler*, 2 vols. (Leipzig: Breitkopf, 1790–92) s.v. "Sporken," is much briefer and does not include these details.

[12] Forkel, "Blechinstrumente," 205. "Man hat auch seit etwa 6 Jahren sogenannte Inventionshörner, wo die Setzstücke oder Krummbogen nicht unterm Mundstücke, sondern in der Mitte des Horns auf einigen hervorstehenden Zapfen angebracht werden."

[13] Gerber, *Historisch-biographisches Lexicon*, s.v. "Sporken," 9.

[14] Heinrich Domnich, "Notice Historique," in *Méthode de Premier et de Second Cor* (Paris: Á l'imprimer du Conservatoire de Musique,1807/8), i-v.

[15] Gerber, *Neues historisch-biographisches Lexikon*, s.v. "Raoux." Gerber does not mention Raoux in the 1790–92 *Historisch-biographisches Lexicon*. Fétis, however, claims that Raoux made a silver instrument for Punto in 1778. François-Joseph Fétis, *Biographie universelle des musiciens et bibliographie generale de la musique*, 2nd edn., 7 vols. (Paris: Firmin Didot Frères, 1866–68), s.v. "Raoux."

[16] Gerber, *Neues historisch-biographisches Lexikon*, s.v. "Türrschmeidt, Carl." "Das erste Instrument, welches er nach diesem seinen Ideale bey dem berühmten Instrumentmacher Raoux zu Paris verfertigen ließ, war sein silbernes Horn, dessen er sich bis an seinen Tod bedient hat."

[17] In the earlier edition (François-Joseph Fétis, *Biographie universelle des musiciens et bibliographie generale de la musiqu*e, 1st edn. [Brussels: Leroux, 1835–44]), Fétis gives 1779 as the date, while the second edition (see above, n. 15), he gives 1778.

[18] Wilhelm Schneider, *Historisch-technische Beschreibung der musicalischen Instrumente*. (Neisse and Leipzig: T. Hennings, 1834), s.v. "Waldhorn."
[19] Giovanni Punto, *Étude ou Exercice Journalier Overage Périodique pour le cor* (Paris: Cochet/Imbault, post 1793, pre 1801).
[20] Anton Joseph Hampel, rev. Giovanni Punto, *Seule et vraie Méthode pour apprendre facilement les éléments des Premier et Second Cor* (Paris: Naderman, ca. 1798).
[21] The André edition of Giovanni Punto's *Étude ou Exercice Journalier Overage Périodique pour le cor* (Offenbach: André, 1801) has a different frontispiece, including an illustration of a fixed-pitch horn without tuning slide.
[22] Johann Heinrich Göroldt, *Ausführliche theoretisch-praktische Hornschule vom ersten Elementar-Unterricht, bis zur vollkommensten Ausbildung* (Quedlinburg: Basse, 1833). The earliest reference found to this work is in the *Allgemeines Verzeichnis der Bücher, welche in der Frankfurter und Leipziger Ostermesse des 1833. Jahres ganz neu gedruckt oder neu aufgelegt worden sind …* (Leipzig: Weidmann, 1833), 159. It is also listed in *Hallisches patriotisches Wochenblatt* 34, no. 42, 19 October 1833, 922.
[23] Carl Klotz, *Practical Instructions for the simple & valve horn/Méthode pratique pour le Cor d'harmonie et le Cor à pistons/Praktische Schule für das einfache und chromatische Horn* (Offenbach: André, 1863).
[24] Friedrich Gumbert, *Praktische Horn-Schule*, 2nd edn. (Leipzig: Rob. Forberg, 1879), 2.
[25] Jacques-François Gallay, *Méthode Pour le Cor*, op. 54 (Paris: Schonenberger, 1843), 5.
[26] Joseph Fröhlich, *Vollständige Theoretisch-pracktische Musikschule für all beym Orchester gebräuchliche wichtigere Instrumente zum Gebrauch für Musikdirectoren - Lehrer und Liebhaber*, vol. 3 (Bonn: Simrock, 1813), 7.
[27] Andreas Nemetz, *Hornschule für das einfache Maschin und Signalhorn*, op. 18 (Vienna: Diabelli, 1829), 3.
[28] Louis Rossmann, illustration, "Das Wald-horn," in *Horn-Schule: Kurze u. praktische Anleitung zur Erlernung des Hornes. Mit 2 Grifftabellen* (Augsburg: A. Böhm & Sohn, 1866), 4. The main difference between the Rossmann and Fröhlich/Nemetz images is that the Fröhlich/Nemetz tuning-slide crook sleeves are female/male tenons while the Rossmann tuning-slide crook sleeves are female/male to male/female tenons.
[29] Göroldt, *Hornschule*.
[30] Adam Wirth, *Praktische, systematisch geordnete Hornschule*, op. 43 (Offenbach: André, 1877), 6.
[31] Ibid., 4.
[32] Frédéric Duvernoy, *Méthode pour le cor, Suivie de Duo et de Trio pour cet instrument* (Paris: A l'Imprimerie du Conservatoire de Musique, [ca. 1802]), 4.
[33] E. Cam, *Méthode de Premier et Second Cor* (Lyon: Arnaud, n.d. [ca. 1827]).
[34] Marc Antoine Jules Corret, *Petite Méthode de Cor contenant un abrégé des principes de musique; l'étendue du premier et second cor, les gammes naturelles, diézé, et bémolisé, des exercices et des airs faciles* (Paris: Meissonnier, [1830/1]) The Meissonnier plate number J.M.504 suggests the date of 1830/1.
[35] Jean-Baptiste Mengal, *Méthode de Cor rédigée d'après les principes du Conservatoire, et suivi du doigté du cornet à pistons*, op. 18 (Paris: Meissonnier, 1835), 2.

[36] Göroldt, *Hornschule*.

[37] Ulrich Hübner, "Das Horn auf dem Porträt von Frédéric Duvernoy," *Jagd-und Waldhörner: Geschichte und musikalische Nutzung: 25. Musikinstrumentenbau-Symposium, Michaelstein, 8. bis 10. Oktober 2004*, ed. Monika Lustig (Augsburg: Wissner; Michaelstein: Stiftung Kloster Michaelstein, 2006), 77–90.

[38] "Sans nous appesantir sur les différences manifestes du cor-solo et du cor d'orchestre, nous ferons remarquer que ce dernier se subdivise en premier et second cors, que ne se distinguent l'un de l'autre que par le degree d'Elévation des sons qu'ils peuvent réaliser…. Le diapason des deux instruments réunis donne une étendue de quatre octaves, que le cor-solo dépasse souvent vers l'aigu; les cors d'orchestre n'usent pas à beaucoup près de cette latitude." *Encyclopédie des gens du monde, répertoire universel des sciences, des lettres et des arts: avec des notices sur les principales familles historiques et sur les personnages célèbres, morts et vivans, par une société de savans, de littérateurs et d'artistes, français et étrangers*, ed. Alexis-François Artaud de Montor, vol. 6 (Paris: Treuttel et Würtz, 1836), 765–66. "Without dwelling on the obvious differences between the *cor solo* and the orchestral horn, we note that the latter is subdivided into first and second horns that are distinguished from each other only by the degree of elevation of the sounds they can play…. The tuning of the two instruments [i.e., the first and second horn] together gives a compass of four octaves, which the cor solo often exceeds in the high range; the orchestral horns do not use much of this latitude."

[39] 24 October 1797. See Thierry Maniguet, "La dynastie des Raoux, facteurs de 'cors de chasse' du XVIIe au XVIIIe siècle," *Musique. Images. Instruments* 15 (2015): 237. Verified by inscription on the bell of Dauprat's Raoux: "PER PRIX DECERNE PAR LE CONSERV.RE DE M.QUE A L DAUPRAT LE 3 B.RE AN 6," i.e., 3 brumaire an 6, or 24 October 1797.

[40] The earliest rules concerning the prizes given at the Conservatoire stated that only students of composition, harmony, declaimed song, song, piano, violin, cello, flute, oboe, clarinet, horn, and bassoon were eligible to compete. See Théodore de Lassabathie, *Histoire du conservatoire impérial de musique et de déclamation* (Paris: Michel Lévy Frères, 1860), 252. Other instruments supplied to the Conservatoire included violins by Charles-François Gand (1787–1845) or Charles Gand (1812–66), flutes by Jean-Louis Tulou (1786–1865, official supplier 1831–1859), clarinets by Auguste Buffet jeune (fl. Paris 1830–after 1885, official supplier until 1868, oboes and bassoons by Georg Triébert (1770–1848) and sons. Scores were given as the prizes for piano, voice, harmony, and composition, and were also given to second prize winners.

[41] Louis-François Dauprat (b. 24 May 1781–d. July 1868).

[42] Jean-Joseph Kenn (1757–1840).

[43] Adolphe Pontécoulant, "Le Cor de M. Dauprat," in *Musée instrumental du Conservatoire de musique: histoires et anecdotes* vol. I (Paris: Lévy-Frères, 1864), 91–98.

[44] Lucien-Joseph Raoux (1752–1823).

[45] See Henri-Jean Garigue, *Grande Méthode de Cor en Fa a deux et a trois pistons* (Paris: Millereau, [ca.1888]), 4–5. Garigue's Méthode was published by Millereau, the successors to Raoux, and includes a portrait (p. 4) of Garigue playing a two-valve cor à pistons complete with "MILLEREAU" stamped on the page as well as an illustration (p. 5) of the various horns "à Raoux" that were available from Millereau.

[46] Joseph Raoux (1725–87).

[47] Maniguet, "La dynastie des Raoux," 226–47, suggests 1776–87.

[48] The relationship between son Lucien-Joseph and father Joseph Raoux had not always been so cozy. On 5 March 1771 Joseph Raoux lodged a complaint of theft "of models for the cutting of hunting horns and horns for music" against his apprentice Corméry (Jean-François Corméry [Courmeri], fl. Paris 1776–before1808) (Paris, Archives nationales, fonds du Châtelet, Y12774). See Maniguet, "La dynastie des Raoux," 233; and *The New Langwill Index*, 71. Corméry had, according to the complaint, been complicit with Lucien-Joseph in the theft.

[49] 1865 testament cited in Tula Giannini, "The Raoux Family of Master Horn Makers in France: New Documents and Perspectives," *Journal of the American Musical Instrument Society* 40 (2014): 121–12.

[50] Marie-Angélique Raoux b. 1751–d. 23 January 1800. Birth year from Maniguet, "La dynastie des Raoux," 237; death date from Giannini, "The Raoux Family," 117.

[51] 13 April 1788. Paris, Archives natioanles, MC CII-541. Marriage contract, Marie-Angélique Raoux and Jean-Joseph Kenn, cited in Giannini, "The Raoux Family," 116.

[52] February 1840. See Maniguet, "La dynastie des Raoux," 237.

[53] Giannini, "The Raoux Family," 132–33.

[54] Martin-Joseph Mengal (b. 27 January 1784, Ghent; d. July 1851, Ghent), also known as Mengal aîné. Studied with Duvernoy. Prizewinner in 1809.

[55] Jean-Baptiste Mengal (b. May 1796, d. 19 December 1878), also known as Mengal jeune. Studied with Domnich. Prizewinner in 1814.

[56] Joseph-Jean-Pierre-Emile Meifred (b. 25 October 1795 according to Fétis, *Biographie Universelle*, s.v. "Meifred, Joseph-Jean-Pierre-Emile"; an alternative date of 13 November 1791 is given by Constant Pierre, *Le Conservatoire National de Musique et de Déclamation* [Paris, 1900], 810). Meifred died 28 August 1867. Studied with Dauprat. Prizewinner in 1818.

[57] Jacques–François Gallay (b. 8 December 1795, d. 18 October 1864). Studied with Dauprat. Prizewinner in 1821.

[58] Paris, Archives nationales, Aj 37 (Archives des Écoles et des Conservatoires à Paris); 319, dossier 2f, letter dated 25 July 1852. Quoted in Cyrille Grenot, "Le Dons de Dauprat au Conservatoire de Paris (Correspondence de 1852 à 1862)," *La Revue du Corniste* 79 (Autumn 2000): 13–25; and 80 (Winter 2001): 9–23.

[59] Paris, Archives nationales, Aj 37 (Archives des Écoles et des Conservatoires à Paris); 321, dossier 6, letters dated 4 February 1895 (M.lle Gallay to the Director of the Conservatoire) and 19 May 1896 (Director of the Conservatoire to M.lle Gallay).

[60] "J'eus le bonheur d'y obtenir le premier prix de Cor, consistant en un instrument de Raoux père, le plus habile fabriquant de son temps. Au repos, comme instrumentiste, depuis que la raison, plus que l'âge, m'a prescrit de m'arrêter, je n'ai jamais pensé à me séparer de la couronne reçue dans ma jeunesse. Aujourd'hui même, je rougirais de le voir décorer la montre d'un marchand. C'est pourquoi, Monsieur le Directeur, je prends la liberté de vous adresser cet instrument pour qu'il soit déposé à la Bibliothèque du Conservatoire. Puissent mes jeunes et futurs Confrères, en voyant le soin que j'ai pris de le conserver, et le scrupule que je me suis fait d'en trafiquer,

(ce que j'ai eu lieu de blâmer plus d'une fois dans les autres), puissent ils dis-je, m'imite. Paris, Archives nationales, Aj 37 (Archives des Écoles et des Conservatoires à Paris); 319, dossier 2f.

[61] See, for example, the Raoux *cor solo*, Bate Collection, University of Oxford (67), dated 1823.

[62] The inventory after the separation of estate property of Marcel-Auguste Raoux and his wife. Paris, Archives nationales, Minutier central, Étude III/1491, 24 February 1836. Quoted and discussed in both Maniguet, "La dynastie des Raoux," 241; and Giannini, "The Raoux family," 129–35.

[63] See list of inscriptions on the instruments listed in Maniguet, "La dynastie des Raoux," appendix 4, 244–45.

[64] Cyrille Grenot "La facture instrumentale des cuivres dans les seconde moitié du XIXe siècle en France," *Romantic Brass: Französische Hornpraxis und Historisch Informierter Blechblasinstrumentbau* (Bern: Edition Argus, 2016), 11–102. See, in particular, the "Tableau des instruments de cuivre fabriqués dans les inventaires," 94–96, which provides statistics of leading French makers of the period.

[65] Distin & Co. instrument made in 1871 by workman Bauer and apprentice Stanton, with crooks for E and E♭. At this time Distin & Co was a trade name of Boosey & Co, London. *Cor solo* serial no. 22918 was sold to the Cumberland Artillery, now in the private collection of Jamie Shield.

[66] See, for example, documents detailing the sale of horns by Raoux to the Opéra (AN AJ13-52 13 January 1802) cited in Giannini, "The Raoux Family," 119.

[67] The horn by Jean-François Corméry dating from 1776–86 in the Museum of the Conservatoire National des Arts et Métiers, Paris (01613), is equipped for tuning-slide crooks using the fixed mouthpipe from E down to B♭ basso and plug-in crooks with integral mouthpipes from F up to C alto; the Raoux horn in the National Music Museum, Vermillion (4082), is equipped for tuning-slide crooks using the fixed mouthpipe from F down to B♭ basso and crooks with integral mouthpipes from G up to B♭ alto.

[68] "De plus, les tons de La, Si b et Ut aigus, sur les instrumens de cette forme, devant, pour ainsi dire, couper l'instrument en deux parties, et rendre nulle l'une des deux coulisses, ainsi que les branches qui s'y rattachent; ces tons présentent une seconde branche d'embouchure qui gène l'executant dans la tenue de son instrument." Dauprat, *Méthode de Cor-alto et Cor-basse*, 1:4. Transl. Jeffrey L. Snedeker, "Méthode de Cor-alto et Cor-basse: Louis François Dauprat," *Historic Brass Society Journal* 4 (1992): 169.

[69] Transl. in Horace Fitzpatrick, *The Horn and Horn-Playing and the Austro Bohemian Tradition, 1680–1830* (Oxford: Oxford University Press, 1970), 224.

[70] Gerber, *Historisch-biographisches Lexicon*, s.v. "Sporken." "Dies sind die wahren verbesserten Inventions=Hörner, welche ihrer Bequemlichkeit wegen in allen großen Kapellen aufgenommen sind. Man verkauft zwar auch noch gegenwärtig in Leipzig sogenannte Inventions=Hörner für alle Töne. Die Liebhaber haben sich aber davor zu hüten. Indem die Veränderungen der Töne noch durch die alten Krumbogen hervorgebracht werden, welche da, wo das Mundstück hingehört, aufgesetzt werden müssen."

[71] Arnold Myers, Robert W. Pyle, Joël Gilbert, D. Murray Campbell, John P. Chick, and Shona Logie, "Effects of nonlinear sound propagation on the characteristic timbres of brass instruments,"

Journal of the Acoustical Society of America 131 (2012), 678–88; Shona Logie, "An Acoustical Study of the Playing Characteristics of Brass Wind Instruments," Ph.D. thesis, University of Edinburgh, 2013.

[72] Arnold Myers, "Characterization and taxonomy of historic brass musical instruments from an acoustical standpoint," Ph.D. thesis, University of Edinburgh, 1998.

[73] Lisa Norman, "An integrated approach to the analysis of eighteenth-century horns," Ph.D. thesis, University of Edinburgh, 2013; Lisa Norman and John Chick, "A systematic survey of variation in design and manufacture of eighteenth-century horns," paper presented at the Historic Brass Society Symposium, New York, July 2012.

[74] Giannini. "The Raoux Family," 126

[75] Norman, "An integrated approach," 169–72.

[76] Robert W. Pyle, "An acoustical comparison of typical German and French hand horns" in *Jagd- und Waldhörner: Geschichte und musikalische Nutzung: 25. Musikinstrumentenbau-Symposium, Michaelstein, 8. bis 10. Oktober 2004*, ed. Monika Lustig (Augsburg: Wissner; Michaelstein: Stiftung Kloster Michaelstein, 2006), 391–410.

[77] Thomas R. Moore, Erin T. Shirley, Isaac E. Codrey, and Amy E. Daniels, "The effects of bell vibrations on the sound of the modern trumpet," *Acta Acustica with Acustica*, 91: 578–89 (2005); Wilfried Kausel, Daniel W. Zietlow, and Thomas R. Moore, "Influence of wall vibrations on the sound of brass wind instruments," *Journal of the Acoustical Society of America* 128 (2010): 3161–74.

[78] The musicians were Claude Maury, Teunis van der Zwart, Alec Frank-Gemmill, Stefan Blonk, Lowell Greer, Thomas Jöstlein, and Anneke Scott.

[79] For example, Alec Frank-Gemmill's use of a *cor solo* by L.-J. Raoux, dated 1823, belonging to Arnold Myers, in the care of the University of Edinburgh (6144), for his recording of the Saint-Saens *Romance in E* and Rossini's *Theme and Variations* (BIS, "A noble and melancholy instrument," BIS-2228) and Anneke Scott's use of the *cor solo* by M.-A. Raoux belonging to the Bate Collection, Oxford (four discs of repertoire by Jacques-François Gallay for Resonus Classics: RES10114, RES10123, RES10153, and RES10228).

[80] Alec Frank-Gemmill.

[81] Teunis van der Zwart.

[82] Anneke Scott.

[83] Thomas Jöstlein.

[84] Claude Maury.

[85] Teunis van der Zwart.

[86] University of Oxford, Bate Collection, 67, dated 1823.